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CANTALOUP MOSAIC INVESTIGATIONS IN THE IMPERIAL VALLEY 1949

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THE PLANT DISEASE SURVEY
DIVISION OF MYCOLOGY AND DISEASE SURVEY

Plant Industry Station   Beltsville, Maryland

CANTALOUP MOSAIC INVESTIGATIONS IN THE IMPERIAL VALLEY, 1949.

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FOREWORD

The following articles report findings of the past season of a joint project set up to study the cantaloup mosaic disease in the Imperial Valley of California by staff members of the University of California and the U. S. Department of Agriculture in cooperation with the Imperial Valley Pest Control Committee. The present work is a continuation of that reported in the Plant Disease Reporter, Supplement 180, January 1949. A summary of the current status of the problem is included.

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VECTOR STUDIES

R. C. Dickson

Aphid populations in the Imperial Valley were much lower in 1949 than in 1948. The sticky-board traps caught only 18.1 percent as many aphids in 1949 as in the previous year, and the actual difference was probably greater between the two years. There was a considerable aphid population in the Valley, however, even in 1949; and the aphids acting as vectors of cantaloup mosaic were the same transient type of population observed the previous year. Aphids did not breed on the melon plants in any appreciable numbers. They came from other crops and from weeds and flew through the melon fields in their search for host plants. Each aphid fed for only short periods on a succession of melon plants. Although attracted enough to land on them, the insect did not find these plants to be suitable food, and moved on after a 40-second sampling. Fifty-two and a half percent of the aphids caught were the green peach aphid, Myzus persicae (Sulz.), which breeds chiefly on sugar beet in this area.

The lower aphid population during the 1949 season was reflected in greatly decreased mosaic damage. The infection percentage in melon plants was much lower than in 1948, and most of the plants that were infected remained healthy until the crop was practically mature. For the Valley as a whole, less than 40 percent of the melon plants contracted mosaic during the 1949 season, in contrast to practically 100 percent infection the previous year.

The lower 1949 aphid population also caused the mosaic to spread more slowly so that in most fields those plants that did become infected had already set and almost matured their melons. Late infections of this type do almost no damage. A few late-planted fields were seriously damaged by the disease.

Attempts to reduce damage from cantaloup mosaic by the use of aphid repellents confirmed the results of the previous season that no known aphid-repellent substance is efficient enough to be practical. Some new insect repellents were tried but tetramethyl thiuramdisulfide was still the only material to have any protecting effect. Tests with this material on a larger scale than in 1948 served to confirm the belief that it is not good enough for a practical control.

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THE OCCURRENCE, DISTRIBUTION, AND SOURCES OF THE CANTALOUP MOSAIC VIRUSES IN 1949

John T. Middleton

Investigations upon the cantaloup mosaic problem during the past growing season were directed towards ascertaining the kinds of cucumber viruses present, their distribution, and some of their sources.

One hundred seventy-nine samples of infected plant material were collected from 53 sampling areas in both the Palo Verde and Imperial Valleys at regular intervals, commencing with the first appearance of the disease on May 9 and concluding on June 13, 1949. Viruses were secured from cantaloup, cucumber, Honeyball melon, Honeydew, Persian melon, squash (Banana and summer types), and watermelon. Inoculations were made with juice extracts, using the carborundum-cotton pad technique, upon a variety of selected hosts. The hosts Cucurbita pepo Duch., Citrullus vulgaris Schrad., and Vigna sinesis Endl. permitted the separation of the viruses into three groups: cucumber virus 1 caused symptoms in all 3 hosts; an undescribed cucumber virus caused symptoms only in squash; squash-mosaic virus caused symptoms only in squash and watermelon. All 3 viruses caused similar symptoms in cantaloup.

Table 1. The occurrence of cucumber virus 1, undescribed cucumber virus, and squash-mosaic virus on cultivated cucurbits in the Palo Verde and Imperial Valleys of California.

Host	Number of Collections	Frequency of viruses recovered: Cucumber 1	Undescribed cucumber	Squash-mosaic
Cantaloup	139	6	9	124
Cucumber	3	0	0	3
Honeyball	8	0	0	8
Honeydew	3	0	3	0
Persian	7	0	1	6
Squash	6	0	0	6
Watermelon	13	0	0	13
Total	179	6	13	160

Apparently the squash-mosaic virus is the most common virus present, followed by the undescribed cucumber virus, and cucumber virus 1 (Table 1). The squash-mosaic virus and the undescribed cucumber virus were found in both the Palo Verde and Imperial Valleys, while cucumber virus 1 was found only in the Imperial Valley. The relative distribution of

these viruses may be expected to vary from year to year, but it would seem apparent that the squash-mosaic virus may remain predominant.

A variety of wild plant material, including native as well as introduced weed plants, was collected that exhibited foliar virus symptoms. Although these studies are incomplete, it may be of interest to report here that both the cucumber virus 1 and squash-mosaic virus have been recovered. Cucumber virus 1 has been secured from *Amaranthus* spp., *Chenopodium* spp., *Datura meteloides* De., *Daucus carota* L., *Lactuca serriola* L., *Physalis* spp., and *Solanum* spp. The squash-mosaic virus was secured from *Cucurbita foetidissima* HBK. and *C. palmata* Wats.

Previous studies indicate that commercial squash plantings are the principal sources of the squash-mosaic virus. Not only is the virus present in squash during the winter and early spring months preceding melon culture, but the virus may be introduced into both squash and melon plantings through planting of viruliferous seed. Likewise, the undescribed virus may be introduced into melon plantings by means of virus-infected seed. It is, therefore, not surprising to find these viruses generally distributed throughout the melon-growing area and perpetuated by means of both susceptible native host plants and contaminated seed stocks.

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MOSAIC REACTIONS OF POWDERY MILDEW RESISTANT LINES OF THE MUSKMELON

G. W. Bohn and Thomas W. Whitaker

The mosaic reactions of 12 inbred lines of powdery mildew resistant cantaloups were compared with those of 3 commercial varieties in randomized plantings at the U. S. Department of Agriculture, Southwestern Irrigation Station, Brawley, California, during the 1948-1949 season. Four replications were planted on each of 3 planting dates, December 14, January 3, and February 10. Other muskmelon lines served as buffers on all sides of the replicated plantings. Each planting occupied 225 foot portions of 8 plant beds. Each block required 2 adjacent beds and consisted of 1 plot of each variety or line. Each plot consisted of 20 plants in adjacent 10-plant subplots in the 2 beds. The plants were arranged in pairs ("hills") 18 inches apart. Two of the plantings were destroyed by inclement weather, leaving the single late planting of 4 replications for analysis.

Planting, thinning, cultivating, and irrigating operations were essentially those used by commercial growers in the Imperial Valley. The plants were covered with waxed paper caps (the east ends opened after emergence) until April 4.

Natural infection by aphid-transmitted viruses occurred later than in preceding years and progressed more slowly. Most of the plants had half-grown fruits at the time of infection. The plots were rated for symptoms of mosaic on four dates from May 17 to June 16, following the appearance of symptoms in all of the plants. The ratings on adjacent subplots were assigned by two judges and combined for analysis. An arbitrary numerical scale was used to rate each subplot as a whole. The mosaic rating classes and the symptoms they indicated are shown below.

Class	Leaf chlorosis	Leaf distortion and size reduction	Plant vigor
4.0	mild	trace	excellent
3.5	moderate	slight	good
3.0	severe	moderate	moderate
2.5	severe	severe	poor
2.0	severe	very severe	very poor

Records were kept, also, of the weights and numbers of ripe marketable fruits, culls, and of 15 fruit characters important to growers, shippers, and consumers. These data will be mentioned only as they are related to the problem of mosaic resistance.

Table 1. Analysis of variance of data on the severity of mosaic symptoms in varieties and selected inbred lines of muskmelons grown in Brawley, California, 1949. Natural infection, 100%. Four readings at intervals of 8 to 12 days. Adjacent beds in two-bed (20 plant) plots scored by two judges. Half-plots (10 plants) scored in arbitrarily selected severity classes.

Source of variation	Degrees of freedom	Sum of squares	Mean square	F [a]	E_{diff}	t at 5%	Sig. Diff.
Varieties	14	47.685417	3.406101	53.69**	0.089	1.98	0.18
Dates	3	7.743228	2.581076	40.68**	0.046	1.98	0.09
Replications	3	0.651562	0.217187	3.42*			
Var. x dates	42	4.577084	0.108978	1.72*			
Var. x Repl.	42	8.543750	0.203423	3.21**			
Dates x Repl.	9	1.592189	0.176910	2.79**			
Error	126	7.993749	0.063442				
Total	239	78.786979					

[a] F values marked with one asterisk (*) are significant at the 5% point; those marked with two asterisks (**) are significant at the 1% point.

Analyses of variance of data from each judging date and the combined data from all dates (Table 1) indicated relatively large and very significant[1] differences in the reactions of different varieties (and lines) and in symptom expression in the entire planting on different dates. The variation among replications was nonsignificant. Small, but very significant variation resulted from the interaction between varieties and replications and from the interaction between dates and replications. The variation resulting from the interaction between varieties and dates was barely significant.

A slight increase in the severity of symptoms during May and early June, and an increase in the vigor of growth of most of the varieties thereafter was reflected in the very significantly different means for dates.

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[1] Variation at odds of 19 to 1 is termed significant; variation at odds of 99 to 1 is termed very significant.

Most of the variation causing significance in the interaction between varieties and replications occurred within 3 of the inbred lines; other lines and varieties had relatively uniform ratings in all replications. The small but very significant variation in this interaction may have resulted from local position effects, or it may indicate that these 3 lines were more sensitive to differences in the environment than were the other lines.

The small but very significant variation that resulted from the interaction between dates and replications, together with the nonsignificant variation among replications, indicated that the disease symptoms were most severe in different replications on different dates. Such differences could result from different stages of progress of the disease in the different replications or from changes in environmental factors in the different replications at different times of the season.

The barely significant variation resulting from the interaction between varieties and dates was of particular interest because each of these variables alone caused great variation. This small interaction indicated the marked agreement of the relative ratings of the different varieties throughout the season.

The data indicated that the differences observed among the lines and varieties were real differences in the severity and duration of mosaic symptoms under the conditions of the experiment, and were little affected by the time of infection and progress of the disease. Together with the data on fruit yields they suggested that the severity of symptom expression was independent of the time of maturity and amount of fruit production. These are very important considerations in utilizing this type of mosaic tolerance in commercial muskmelon production. Whether these differences were differences in mosaic tolerance _per se_ or differences in vigor and/or water or nutrient requirements remains to be determined.

The means of the variety ratings on different dates and the grand variety means are shown in Table 2. Tukey's[2] procedure for comparing means separated the varieties and inbred lines into 3 groups. Group 1 included 8 inbred lines with a grand mean mosaic index of 3.01. These inbred lines developed only moderate symptoms of mosaic and continued to grow vigorously. Group 2 included the single variety Sulfur Resistant V-1 with a mean mosaic index of 2.64. This variety developed severe symptoms of mosaic but continued to grow with moderate vigor. Group 3 included 4 inbred lines and the varieties Powdery Mildew Resistant Cantaloup Number 5 and Powdery Mildew Resistant Cantaloup Number 6, with a mean mosaic index of 2.38. These lines and varieties developed very severe symptoms of mosaic and grew with little vigor following

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[2] Tukey, J. W. Comparing individual means in the analysis of variance. Biometrics 5: 99-114. 1949.

Table 2. Severity of mosaic symptoms in varieties and inbred lines of muskmelons at Brawley, California, 1949.

Variety or line	Date rated: May 17	May 25	June 6	June 16	Grand means[a]	Group
		variety mean ratings				
34574	3.19	3.00	2.94	3.25	3.09	1
34663	2.94	2.94	3.00	3.50	3.09	1
34619	2.94	3.25	2.94	3.13	3.06	1
34622	2.94	3.06	2.88	3.48	3.06	1
34661	2.75	3.06	3.00	3.48	3.05	1
33952	3.00	2.94	2.94	3.25	3.03	1
34610	2.75	2.31	2.81	3.06	2.86	1
34575	2.75	2.69	2.88	3.13	2.86	1
Sulfur-resistant V-1	2.63	2.56	2.56	2.81	2.64	2
34030	2.50	2.44	2.31	2.81	2.52	3
Powdery Mildew Resistant No. 6	2.50	2.44	2.38	2.56	2.47	3
34003	2.50	2.31	2.19	2.50	2.38	3
34145	2.38	2.38	2.19	2.50	2.36	3
Powdery Mildew Resistant No. 5	2.56	2.31	2.06	2.44	2.34	3
24102	2.31	2.13	2.00	2.50	2.23	3
Date means	2.71	2.69	2.60	2.95	2.74	

[a] The least significant difference between grand means of varieties at odds of 19 to 1 equals 0.18.

infection.

Unfortunately, none of the 8 inbred lines with superior mosaic tolerance was considered suitable for commercial muskmelon production. Although these lines were equally as good as (or occasionally superior to) the commercial varieties in most of the important economic characters, each line lacked at least one character essential for an economic passport. These lines did possess many characters that indicate their value as parental stocks in the breeding program. The data obtained in this experiment suggested that the mosaic tolerance occurring in these lines has a potential economic value.

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LA JOLLA, CALIFORNIA

CANTALOUP MOSAIC, AS AFFECTED BY NITROGEN FERTILIZATION

F. W. Zink and G. N. Davis

Observations in commercial plantings by other investigators have indicated that satisfactory yields of melons could be obtained despite the presence of cantaloup mosaic virus, if the crop was carefully handled as to irrigation and fertilization to stimulate vigorous growth. The more common fertilizer regimes for cantaloups in the Imperial Valley include the application of 300 lb. per acre of super phosphate, broadcast before making the plant beds or, more commonly, banded in the row at planting or thinning. Nitrogen fertilizers are applied on other crops in the rotation but are usually omitted from the fertilizers applied during the growth of cantaloups. Occasionally, 60 pounds of nitrogen, as ammonium nitrate or ammonium sulfate, per acre are applied as side dressings after emergence of the cantaloups. The purpose of the study was to determine:

1. Whether the application of nitrogen fertilizer above the normal amounts through the growing season would alleviate the severity of the disease.
2. Whether such application of nitrogen would delay the maturity of the fruit.
3. Whether such application would affect the sugar content of the fruit.

Procedure

Four test areas were selected in different localities in the Imperial Valley. Each test area was planted to a different variety as shown below.

Test Area I.	Powdery Mildew Resistant Cantaloup No. 5 at the Meloland Station.
Test Area II.	Powdery Mildew Resistant Cantaloup No. 45 at the N. J. Vanoni Ranch, west of El Centro.
Test Area III.	Growers Selection K-1 at the S. A. Gerrard Ranch, north of Brawley.
Test Area IV.	Powdery Mildew Resistant Cantaloup No. 6 at the Western Fruit Growers Ranch, Tamarack District.

Four treatments were applied to each test area as follows:

1. 60 pounds of nitrogen per acre was applied 2 to 3 weeks after planting (check).

2. 60 pounds of nitrogen per acre was split into four applications and applied at intervals through the growing season.
3. 120 pounds of nitrogen per acre was split into four applications and applied at intervals through the growing season.
4. 180 pounds of nitrogen per acre was split into four applications and applied at intervals through the growing season.

The nitrogen (ammonium nitrate) was drilled to a depth of 1 inch along the side of the furrow approximately 8 inches from the plants. All treatments received 80 pounds of P_2O_5 per acre three to four weeks after planting. This phosphate (triple superphosphate) was drilled in to a depth of 7 inches along the side of the furrow and approximately 6 inches from the plants. Each treatment consisted of two 300 foot beds; an area of approximately 1/11.1 of an acre. Records were taken of vine condition and severity of virus infection. Yield data from each harvest consisted of the number of marketable fruit, weight of marketable fruit, number of cull fruit, and weight of cull fruit. Five cantaloups were selected at random from each treatment on four consecutive harvests, and refractometer readings were taken of these melons to determine percentage of soluble solids.

Observations

Mosaic appeared in Test Area I on April 21, and by the 5th of May the field was approximately 100 percent infected. Compared with the other treatments, plants in treatment 1 were more vigorous throughout the season and produced fewer shoots with stunted leaves. Symptoms on plants in treatment 1 were limited to distortion of leaf margins and moderate chlorosis of leaves. Treatments 2, 3, and 4 recovered from stunted leaf growth and appeared to be quite vigorous at harvest.

Symptoms of mosaic were first noticed in Test Area II on May 3 and by May 14 it was approximately 100 percent infected. Plants in treatments 2, 3, and 4 appeared to be more vigorous than in treatment 1. Virus symptoms in this test area were limited to distortion of leaf margins and moderate chlorosis. The field was severely infected with powdery mildew. This disease reduced the yield considerably.

Test Area III showed the most severe symptoms of the disease. Mosaic was observed first on May 6, and at that time the plot was approximately 100 percent infected. Treatments 3 and 4 had considerably better vine growth than treatments 1 and 2 at harvest. By June 10 treatments 1, 2, and 3 showed severe chlorosis and severe distortion of leaf margins. Treatment 4 continued to look vigorous until the end of the harvest period.

Table 1. Summary of harvest records for 1949 cantaloup mosaic study. Yield per acre was recorded in Jumbo 36 crates; mean weight of fruit, in pounds.

Treatment	Crates Per Acre	Mean Weight Marketable Fruits	Mean Weight Cull Fruits	Percent of Fruit culled
		Test Area I		
1	171.5	2.44	1.1	28.8
2	132.6	2.60	1.6	21.9
3	143.3	2.75	1.6	32.7
4	134.8	2.76	1.5	39.3
		Test Area II		
1	80.5	2.48	1.30	19.7
2	113.0	2.36	1.77	17.7
3	97.8	2.31	1.63	20.8
4	103.2	2.39	1.71	11.6
		Test Area III		
1	96.6	2.39	1.66	48.3
2	99.1	2.35	1.63	40.8
3	99.4	2.34	1.65	37.4
4	63.3	2.46	1.62	38.5
		Test Area IV		
1	171.4	2.61	1.90	34.7
2	180.0	2.66	1.79	35.4
3	183.0	2.75	1.80	38.3
4	181.9	2.67	1.88	38.2

Test Area IV showed the least injury from the disease. Symptoms of mosaic in this field were first noticed on May 10, and by May 15 infection was approximately 100 percent. Symptoms were limited to mild chlorotic mottling. In this area there appeared to be no differences between treatments in regard to disease symptoms or in growth of vines.

Results

Analysis of harvest records (Table 1) indicates that the severity of the cantaloup mosaic disease as reflected in yield was not alleviated by use of nitrogen fertilizer. In none of the test areas did treatments 3 or 4

increase yield sufficiently to warrant heavy applications of nitrogen.

All treatments for any one given test area seemed to mature fruit at the same rate and to reach peak production at approximately the same date. There appeared to be no delay in maturity of fruit as a result of nitrogen application.

Analysis of variance for total soluble solids content of the fruits indicated that there was no significant difference between treatments in any of the test areas. Therefore, nitrogen fertilization at the rates applied did not have any effect on soluble solids content of fruit.

When this study was undertaken there appeared to be some evidence to suggest that satisfactory yields could be obtained in a virus-infected field if proper horticultural practices were followed. The results of this year's investigation indicate that the severity of the mosaic disease as reflected by plant symptoms and yields was not alleviated by the use of nitrogen fertilizer.

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DIVISION OF TRUCK CROPS
UNIVERSITY OF CALIFORNIA
MELOLAND EXPERIMENT STATION
EL CENTRO, CALIFORNIA

PRESENT STATUS OF CANTALOUP MOSAIC IN THE IMPERIAL VALLEY

Thomas W. Whitaker, John T. Middleton,
R. C. Dickson, G. W. Bohn,
F. W. Zink, and G. N. Davis

The cantaloup mosaic investigations in the Imperial Valley have produced some useful, fundamental information upon which the successful control of the disease may ultimately be based. It seems desirable to summarize the status of our present knowledge of the disease.

At least three viruses occur on muskmelons in the Imperial Valley. These three viruses can be identified by their effects, or lack of effects, upon the three differential hosts *Cucurbita pepo* L., *Citrullus vulgaris* Schrad., and *Vigna sinensis* Endl. The three viruses produce similar symptoms on *Cucumis melo* L. The squash-mosaic virus predominated in 1949 collections, but the relative importance of the different viruses may be expected to vary from year to year.

Sources of the viruses include muskmelon and squash seed, cultivated squashes, and several introduced and native weed species. A permanent reservoir of the virus is probably established in the wild (some of them perennial) and cultivated plants growing in the area.

The disease is carried to the muskmelon fields and spread within the fields principally by aphids. The species involved do not prefer muskmelons as host plants but pause briefly to feed upon them during their migratory search for a more suitable food supply. The habit of feeding briefly on numerous individual plants, including muskmelons and many related and unrelated species, during the migration is a major factor in the disease problem. It contributes to the extreme efficiency of these insects in transmitting the viruses and to the lack of effectiveness of insecticides in controlling the disease.

The predominant species of aphid in the area is the green peach aphid, *Myzus persicae* (Sulz.). This species is a proven vector of the three known viruses and is presumably the main vector of the cantaloup-infecting viruses in the area. It breeds chiefly on sugar beets in the Imperial Valley, migrating in enormous numbers in March and April in a search for additional host plants. The sugar beet apparently does not harbor the viruses.

The increasing prevalence of mosaic in muskmelons in the Imperial Valley has been correlated with the increasing area devoted to sugar beets. During the past two seasons the prevalence and rate of spread of mosaic in muskmelons has been correlated with the numbers of aphids involved in the spring migrations.

Tests with numerous insecticides indicate that mosaic cannot be controlled through the application of insecticides in the muskmelon fields. The effects of premigration insecticide applications in the beet fields and elsewhere have not been studied sufficiently to permit estimates of possible value or recommendations for their use.

Tests of more than 600 accessions of Cucumis, mostly from Asia, have yielded some stocks with moderate degrees of resistance or tolerance to one or more of the viruses, but neither immunity nor extreme resistance has been found. Some of these stocks are being used in the breeding program in the effort to combine greater tolerance to mosaic with resistance to powdery mildew and the several other economic characters required in a shipping variety suitable for culture in the Imperial Valley.

Less marked degrees of variation were found in the inbred lines of powdery mildew resistant cantaloups than in the foreign plant accessions. A single year's results indicated that certain lines were more tolerant of mosaic than were the commercial varieties now in use. Further work will be required to incorporate into single lines all of the characters required for successful commercial production.

Observations on commercial fields suggested that some cultural practice or practices may affect the response of muskmelons to mosaic. A single year's results with nitrogen fertilizer indicated that applications of this nutrient above normal usage did not increase or decrease mosaic symptoms, vine vigor, yields, or soluble solids in naturally infected fields. The effects of other nutrients and irrigation practices remain to be studied.

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